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ETHANOL-INDUCED CHANGES IN PERFORMANCE AND MOOD IN RELATION TO --ETC(U)

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**ETHANOL-INDUCED CHANGES IN PERFORMANCE AND MOOD
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D. M. SEALES, P. NAITOH, L. C. JOHNSON

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ETHANOL-INDUCED CHANGES IN PERFORMANCE AND MOOD IN
RELATION TO ACQUIRED TOLERANCE IN SOCIAL DRINKERS

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Report No. 78-6

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ABSTRACT

The purpose of this study was to evaluate the usefulness of two measures of performance and one measure of mood as indicators of degree of acquired tolerance to ethanol in social drinkers. Eleven social drinkers (2 light, 4 moderate, 5 heavy) participated in 8 hours of repetitive testing on each of 2 nonconsecutive days, placebo and drug. A twelfth subject, with moderate drinking history, became ill following ingestion of ethanol on the drug day. His data was dropped from analysis. Ethanol induced significant alterations in mood, and significant decreases in serial reaction time and Stipple-cancellation performance. Changes in mood and Stipple-cancellation performance did not correlate significantly with drinking history. Loss of data due to equipment failure precluded analysis of serial reaction time data in relation to drinking history. Evidence is considered that the present ethanol dosage (0.9g/kg) may not have been sufficient, that a wider range of drinking histories was needed, and that electrophysiological/psychophysical measures may be more useful than the present performance and mood tests in the search for measures of acquired tolerance to ethanol in social drinkers.

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INTRODUCTION

This paper is concerned with acquired tolerance to ethanol¹ in social drinkers². More specifically, the paper examines ethanol-induced changes in performance and mood as indicators of degree of acquired tolerance. Few studies have recognized and concentrated on the existence of varying degrees of acquired tolerance in purely nonalcoholic human populations. Goldberg (1) is a classic exception. When given ethanol, abstainers showed greater disruption of sensory, motor and cognitive ability than did moderate drinkers; and moderate drinkers in turn showed more disruption than did heavy drinkers. More recently, Goodwin (2) noted that moderate drinkers given ethanol took fewer "risks" and performed significantly better on a motor task than did light drinkers. These results suggest that there is a measurable range of acquired tolerance in social drinkers. Further, these results suggest that changes in performance can be used to indicate the presence and degree of acquired tolerance.

The present study evaluated the usefulness of two measures of performance as indicators of degree of acquired tolerance to ethanol in social drinkers. In addition, a measure of self-perceived mood was employed to determine if mood change also is sensitive to acquired tolerance in social drinkers.

METHOD

Twelve males (age 25 to 39 years, mean 31) were chosen from a group of 55 on the basis of their responses on a drinking history questionnaire devised by Cahalan and Cisin (3). On the scale described by these authors, 2 subjects qualified as light drinkers, 5 as moderate, and 5 as heavy. A drinking history score was derived from the questionnaire for each subject. The score consisted of the amount of ethanol imbibed in the previous 6 months, divided by the weight of the subject (Table 1). For purposes of this study, it was assumed that degree of acquired tolerance to ethanol varied directly with extent of drinking experience.

Each subject was studied during 2 nonconsecutive days. The placebo day was first. Three drinks were served, each of 200 ml orange juice with sufficient quantity of 95% USP ethanol floated on top (2 ml per drink) to resemble the odor of an actual mixed drink. The drug day was second. Subjects received 0.9 g/kg ethanol in 3 equal drinks of 200 ml orange juice. Each drink was imbibed over a period of 10 min.

Fig. 1 illustrates the daily schedule. Subjects had fasted for at least 4 hours before the start of the experiment, usually since the preceding evening meal. They were

given a light breakfast (toast). Testing began at 0930, and continued in half-hour sessions. Drinks were given from 1030-1100, lunch was from 1230-1300, and there was a relaxation period from 1430-1500.

Each half-hour testing session was organized as shown in Fig. 2. The Bourdon-Wiersma Stipple Test required the first 5 min of the session. This was followed by 10 min of EEG and evoked potential recording (data presented in a separate publication, (4)). A breathalyzer reading (Smith & Wesson Model 1000) was then obtained³. Finally, subjects performed the Wilkinson Four-Choice Serial Reaction Time Task for 4 min. Any time remaining in a half-hour session was used for relaxation.

The Bourdon-Wiersma Stipple Test (5) consisted of crossing out groups of 4 dots (stipples) on a page constituted of 25 rows of groups of 3, 4, and 5 dots. The test was chosen because of its similarity to the Bourdon Letter Cancellation Test, previously shown to be sensitive to the effects of ethanol (1). The method of van Wulfften Palthe (5) was followed in deriving a performance score based on a weighted combination of four parameters: the number of omissions, the number of commissions, the range of time to complete each of 25 rows, and the total time to complete 25 rows.

The Wilkinson Four-Choice Serial Reaction Time Task (6) is a newly available version of the Leonard Serial Reaction Time Task (7). Subjects press one of four buttons to extinguish one of four lights arranged in a response-compatible manner in the four corners of a square above the response keys. Any one of the four lights relights at random 120 msec following a button press. Three aspects of serial reaction time performance were examined: (1) mean reaction time for correct responses, (2) the mean difference between the means of the 10 slowest and the 10 fastest response times in each 4 min testing session, and (3) the number of gaps (arbitrarily defined as response times greater than 1 sec). In both behavioral tasks, subjects were instructed to respond as accurately and as quickly as possible.

In addition, the "How are you feeling right now" form of the Profile of Mood States (POMS) was given four times each day at 0815, 1055, 1255 and 1455 hours (see Fig. 1). The six scales of the POMS (Vigor, Tension, Anger, Depression, Confusion-Bewilderment and Fatigue) were examined separately, each by a two-factor, repeated measures analysis of variance. The two factors were time of day (factor A) and day (factor B). Conservative degrees of freedom (1 and 10) were used.

Statistical analyses of performance data were accomplished by means of t-tests within days. Certain data were grouped in order to reduce the total number of planned comparisons. Specifically, data from the two morning sessions of the pre-drink period were compared. If they did not differ, an average pre-drink value was used. If they did differ the 1000-1030 performance value was used. Further, an average value for comparison against same-day pre-drink performance was derived from the three sessions of the midday period and another average value from the afternoon period. This was possible because of the gradual changes in BAC and performance evident in these periods. BAC and performance changed more rapidly and markedly in the three sessions of the morning period. Accordingly, morning session performance scores (three) were evaluated separately against same-day pre-drink value. In all, six planned comparisons were performed for each day of Stipple-cancellation performance. The same six comparisons were made for each day of serial reaction time performance but for each of the three modes of scoring: mean reaction time, mean difference of fastest and slowest reaction times, and gaps. Statistical significance was based upon a level of .05. A Dunn-Bonferroni criterion (8) of .05/6 is suggested however as a means of control for chance significance due to multiple planned comparisons on related data. Performance comparisons which did not meet the conservative level of significance are marked with the superscript "x". All statistical comparisons were two-tailed with 10 degrees of freedom unless otherwise specified. Mood and Stipple-cancellation performance measures as described above were transformed into percentage-change from pre-drink values for correlation (Spearman rho) with the rank-ordered drinking histories of the 11 subjects^x. Rank-order correlation was employed because the interval nature of the drinking history scores, based on subjective reports on a questionnaire, was not certain.

RESULTS

BAC values. Mean BAC values are plotted in the upper portion of Fig. 1. On the placebo day (dashed line), mean BAC remained at or below the 10 mg% noise level of the Breathalyzer, except in the morning period when the 6 ml of ethanol used in the placebo drinks produced a slight increase in BAC. On the drug day (solid line), mean BAC rose rapidly to peak at about 1145 of the morning period, and then fell slowly. Six subjects showed peak BAC at the 1145 measurement, 1 at 1115, 3 at 1215, and

1 at 1315. Peak BACs ranged from 77-121 mg% (mean 94). The subject who would have been ranked as the fourth lightest drinker became ill immediately following the drinking session. He was excused from the study, and his data were excluded from analysis.

Stipple test. Mean-weighted scores from the Stipple test are plotted in Fig. 3. The only significant change in performance over the course of the placebo day (dashed line) occurred from the first testing session of the pre-drink period to the second ($t = 3.744$). This was presumably a rapid and marked learning effect; 0930-1000 values were discarded from further analysis. Overall performance scores tended to improve during the remainder of the placebo day as the number of correct detections increased, but this tendency did not reach significance. On the drug day (solid line), pre-drink performance was significantly improved over that observed during the 1000-1030 testing session of the placebo day ($t = 2.399^X$). After ethanol had been imbibed at a steady rate from 1030 to 1100, Stipple performance remained essentially unchanged until the 1130-1200 testing session when a significant decrement in the overall Stipple performance score was observed ($t = 2.862^X$). Performance decrements consisted of more seconds to complete the test ($t = 2.184^X$), with greater variability of time required per line ($t = 2.273^X$). At the same time, the number of omissions and commissions changed insignificantly. Stipple performance scores were still significantly reduced from pre-drink values during the 1200-1230 ($t = 2.322^X$) and 1400-1430 ($t = 2.692^X$) testing sessions.

Wilkinson Four-Choice Serial Reaction Time Task. Fig. 4 shows mean reaction time data on both the placebo (dashed line) and drug (solid line) days. Variations in mean reaction time were similar to those of mean weighted Stipple scores. That is, on the placebo day, mean reaction time improved significantly from the first to the second testing session of the pre-drink period ($t = 2.611^X$, $df = 5$). Then, mean reaction time remained about the same throughout the remainder of the placebo day. Significant ethanol-induced lengthening of mean reaction time occurred on the drug day during the 1100-1130 ($t = 3.393^X$, $df = 6$) and 1130-1200 ($t = 3.539^X$, $df = 6$) testing sessions.

The nature of the significant change in the mean response time on the drug day was made more clear by an examination of the mean difference between the fastest and slowest response times. This difference increased significantly in all three sessions of the morning period ($t = 5.800$, 4.315^X , 2.983^X ; $df = 4$). The change was comprised

of a slowing of the slow response times by a mean of 108 msec, while fast response times remained essentially unchanged during the morning period, the time of most acute alcoholization. The lengthening of slow response times occurred in each min of the 4 min sessions.

Mean number of gaps increased significantly from the pre-drink to all three testing sessions of the morning period on the drug day ($t = 2.875^X, 2.628^X, 3.386^X$; $df = 6$). No such changes were observed on the placebo day.

POMS. The Anger and Depression scales showed no significant effects, but the subjects did report changes in Fatigue, Tension, Confusion-Bewilderment and Vigor. Fatigue scores increased gradually over the course of both days. The only significant increase above the pre-drink values occurred by the late afternoon period (1455) of the drug day ($t = 3.840$). Confusion-Bewilderment scores increased significantly from the pre-drink (0855) to the immediate post-drink (1055) measurement on the drug day ($t = 3.602$). Tension scores gave significant main and interaction effects ($F_A = 6.750$; $F_B = 16.536$; $F_{AB} = 4.409$). The significant interaction arose because time of day (factor A) was a significant influence on only the placebo day: tension was highest during the preparatory period, falling significantly thereafter ($t = -2.355, -3.467, -3.881$). On the drug day, tension scores remained low and about the same at all four measurements. Vigor showed a main effect for day ($F_B = 10.204$), with mean scores on the drug day lower than on the placebo day, except at the 1455 measurement.

Drinking History⁵. Degree of change in overall Stipple performance did not correlate significantly with rank-order of drinking history. When considered separately, the degree of change in amount of time to complete the Stipple test and the range of time per line also did not correlate significantly with drinking history. Correlations with serial reaction time data were not calculated since complete data from only five subjects were available⁴. The following significant changes in mood on the drug day were examined in relation to drinking history: (1) the increase in Confusion-Bewilderment from the pre-drink to the immediate post-drink measurement, (2) the increase in Vigor from the pre-drink to the immediate post-drink measurement, and (3) the increase in Fatigue from the pre-drink to the last post-drink measurement (1455). None of these correlations were significant. The Vigor scale of the POMS did, however, show an interesting pattern of activity in the 5 min before the cessation

of drinking (1055 measurement) when individual percentage changes in Vigor from 0815 to 1055 were scrutinized. Table 2 shows that 6 of the 8 lightest-ranked drinkers reported decreased Vigor at 1055 (mean 12% decrease) while the 3 heaviest-ranked drinkers reported enhanced Vigor (mean 33% increase).

DISCUSSION

The purpose of this study was to examine two measures of performance and one measure of mood as indicators of degree of acquired tolerance to ethanol in social drinkers. Behavior and mood showed significant changes resulting from the ingestion of ethanol. Changes in mood and in Stipple-cancellation performance did not correlate significantly with drinking history. Loss of data due to equipment failure precluded analysis of serial reaction time performance in relation to drinking history.

Underlying the lack of correlation between performance or mood and drinking history is the possibility that acquired tolerance to ethanol does not vary measurably in social drinkers. This is contrary to the results of Goldberg (1) and of Goodwin et al. (2) which showed greater disruption of performance in lighter drinkers, and it seems contrary to common sense. Also, the dissociation in the present Vigor data between lighter and heavier drinkers suggests the presence of differential degrees of acquired tolerance. Some other explanation for the lack of correlation with drinking history is more likely.

In addition, the small N may be that the range of drinking histories in the present sample of social drinkers was insufficient. Specifically, none of the 11 subjects qualified as an abstainer or as an infrequent-light drinker, the two lowest categories on the scale suggested by Cahalan and Cisin (3). This occurred because some of these potential subjects refused to participate in the study, and, presumably, because some did not complete or return the questionnaire. Thus, the lack of abstainers and infrequent-light drinkers may have contributed to the lack of significant correlations between drinking history and performance or mood.

A related consideration is that maybe these social drinkers were not given enough ethanol. Fig. 1 of Goldberg (1) shows that in a sample of 700 individuals judged by medico-legal means as "under the influence" less than 10% had a BAC as low as 100 mg% (the object BAC of the present work). About 70% of the Goldberg population has BACs ranging from 140 to 250 mg%. The present dosage (0.9g/kg) was just slightly more than Goldberg (1) administered to his abstainers (0.63-0.80g/kg), and was well below the

dosages given to his moderate (1.00-1.42g/kg) and heavy (1.20-1.35g/kg) drinkers. Also, the present mean BAC (94 mg%) was below the median BACs reported by Goodwin et al. (2): 110 mg% for heavy drinkers and 105 mg% for light drinkers.

All of the significant effects in this study in relation to ethanol occurred in the morning period, and most markedly in the first two sessions of the morning period when 7 of 11 subjects had not yet reached peak BAC. This means that in future similar attempts to correlate changes in performance and mood with drinking history it may not be necessary to test much more than two hours post-ingestion. This would be a substantial savings in time, and it would mean that subjects could sleep during most of the descending phase when they are feeling the depressive effects of the ethanol. Our findings are consistent with those previously reported (9) to the effect that cognitive ability is disrupted more on the ascending than the descending phase of the BAC curve. Performance and mood data probably become more unreliable during the descending phase when practice, motivation and fatigue effects are greatest. Finally, Jones (10) reported that medical students differed on an introversion-extroversion scale during the descending phase. This suggests that personality factors also may contribute to variability during the falling BAC phase.

An important inference from our data is that electrophysiological and/or psychophysical measurements may be more sensitive to relatively low dosages of ethanol than are behavioral tests. Seales et al. (4) reported on the somatosensory evoked potential (SEP) and tolerance data which formed part of the present experiment. These authors confirmed the finding of Salamy and Williams (11) that ethanol significantly reduces the amplitude of the late waves (100-400 msec) of the SEP recorded from a vertex scalp lead. More important, however, Seales et al. (4) observed a significant correlation between the amount of SEP decrement and drinking history: lighter drinkers showed greater SEP decrement. After a review of the literature concerning critical flicker fusion (CFF) and ethanol, Hill et al. (12) noted that in nonalcoholics of unspecified drinking history, dosages as low as 0.44 g/kg can cause change of CFF threshold. The specific effect of ethanol on CFF is, however, controversial.

SUMMARY

Ethanol induced significant alterations in mood, and significant decreases in

serial reaction time and Stipple-cancellation performance. Changes in mood and in Stipple-cancellation performance did not correlate significantly with the subjectively-derived measures of drinking history. Loss of data due to equipment failure precluded analysis of serial reaction time performance in relation to drinking history. Due to the small N and limited range of drinking history, these results should be viewed as tentative.

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FOOTNOTES

¹An individual has an "acquired tolerance to ethanol" when, as a result of repeated exposure, an increased amount of the drug is required to produce the same degree of effect, or less effect is produced by the same dose of the drug (13, P. 137).

²A "social drinker" is defined as one who by social, medical, economic and legal criteria is not considered an alcoholic (14).

³Readings of the Model 1000 agree closely with actual blood alcohol concentration (15).

⁴Due to technical failure of the Wilkinson Four-Choice Serial Reaction Time device, data were available from only 6 subjects on the placebo day, 7 subjects on the drug day, and 5 subjects on both days. The small N did not allow computation of stable correlations between serial reaction time performance and drinking history.

⁵The following "control" variables did not correlate significantly with drinking history: weight, age or BAC characteristics including ascending and descending slope, peak, time to peak, or mean pre-drink value.

TABLE 1

Drinking History Scores and Drinking Classifications

| <u>Subject Rank *</u> | <u>Ethanol in 6 mo. (ml)</u> | <u>Weight Kg</u> | <u>Drinking History Score (ml/Kg)</u> | <u>Cahalan and Cisin Drinking Classification</u> |
|---------------------------|----------------------------------|----------------------|---|--|
| 1 | 6.3 | 73 | 0.086 | light |
| 2 | 9.9 | 78 | 0.127 | light |
| 3 | 11.5 | 68 | 0.169 | moderate |
| 4 † | 25.3 | 70 | 0.361 | moderate |
| 5 | 27.5 | 61 | 0.451 | moderate |
| 6 | 37.3 | 80 | 0.466 | moderate |
| 7 | 89.5 | 80 | 1.119 | moderate |
| 8 | 99.9 | 75 | 1.332 | heavy |
| 9 | 162.3 | 97 | 1.673 | heavy |
| 10 | 159.4 † | 81 | 1.968 | heavy |
| 11 | 250.8 | 68 | 3.688 | heavy |
| 12 | 318.0 | 82 | 3.878 | heavy |

* Subject rank 1 was lightest drinker

† Became ill on drug day; dropped from study

TABLE 2

| <u>Rank-Order of Drinking History</u> | <u>Percent Increment (+) or Decrement (-) in Vigor from 0855 to 1055</u> | <u>Spearman Rank- Order Correlation</u> |
|---|--|---|
| 1 | +20 | 0.50 (ns) |
| 2 | -23 | |
| 3 | -17 | |
| 4 | 0 | |
| 5 | - 6 | |
| 6 | - 3 | |
| 7 | -13 | |
| 8 | -11 | |
| 9 | +19 | |
| 10 | +56 | |
| 11 | +25 | |

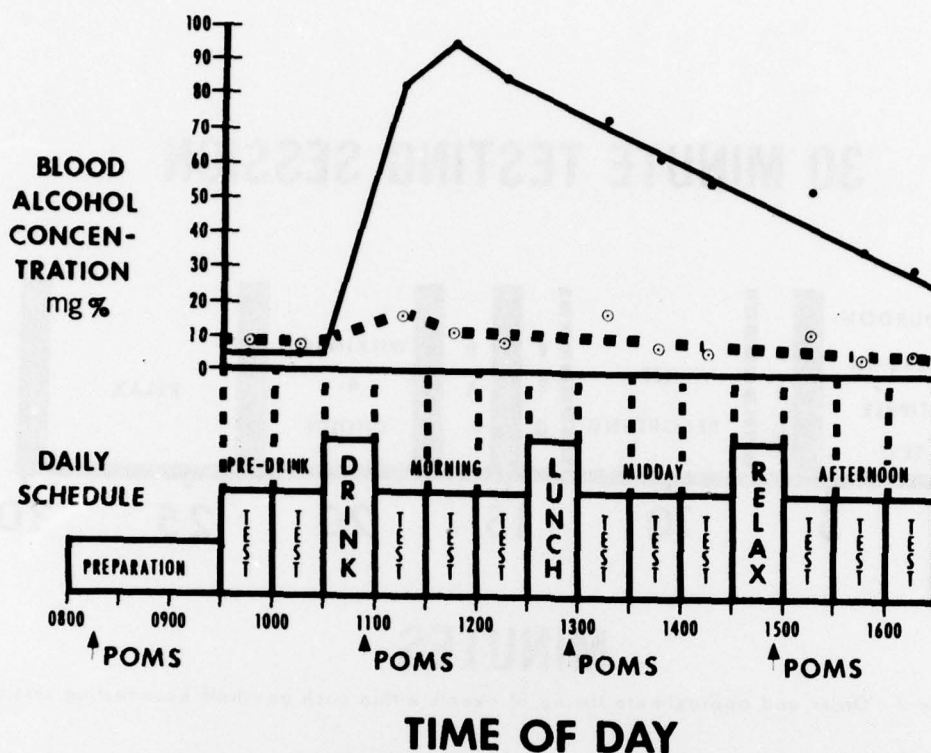


Figure 1. Lower portion: Daily testing schedule. Upper portion: Time course of mean blood alcohol concentration (BAC) on the placebo (dashed line) and drug (solid line) days. BAC curves were fitted to data points visually.

30 MINUTE TESTING SESSION

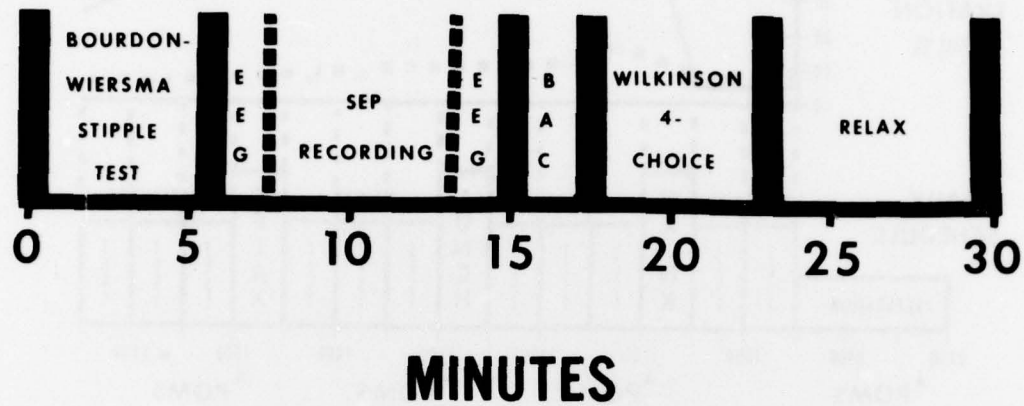


Figure 2. Order and approximate timing of events within each one-half hour testing session.

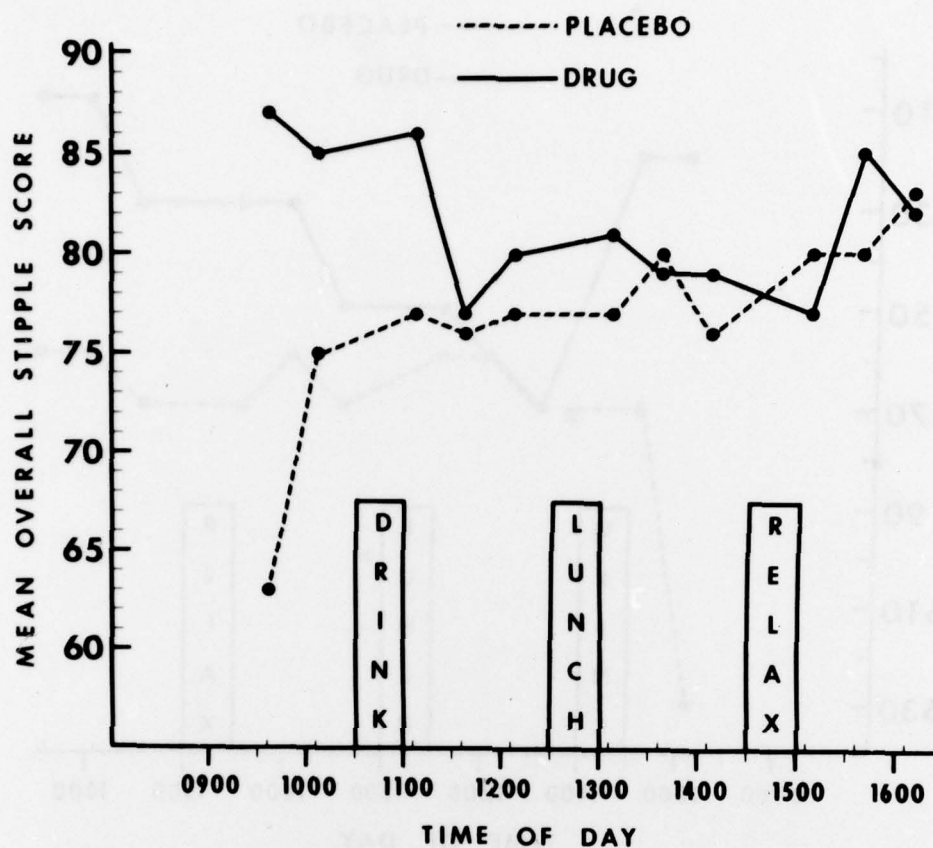


Figure 3. Mean overall Stipple performance as a function of testing session. High score indicates better performance. Tick marks are placed at the approximate time of testing within a half-hour session.

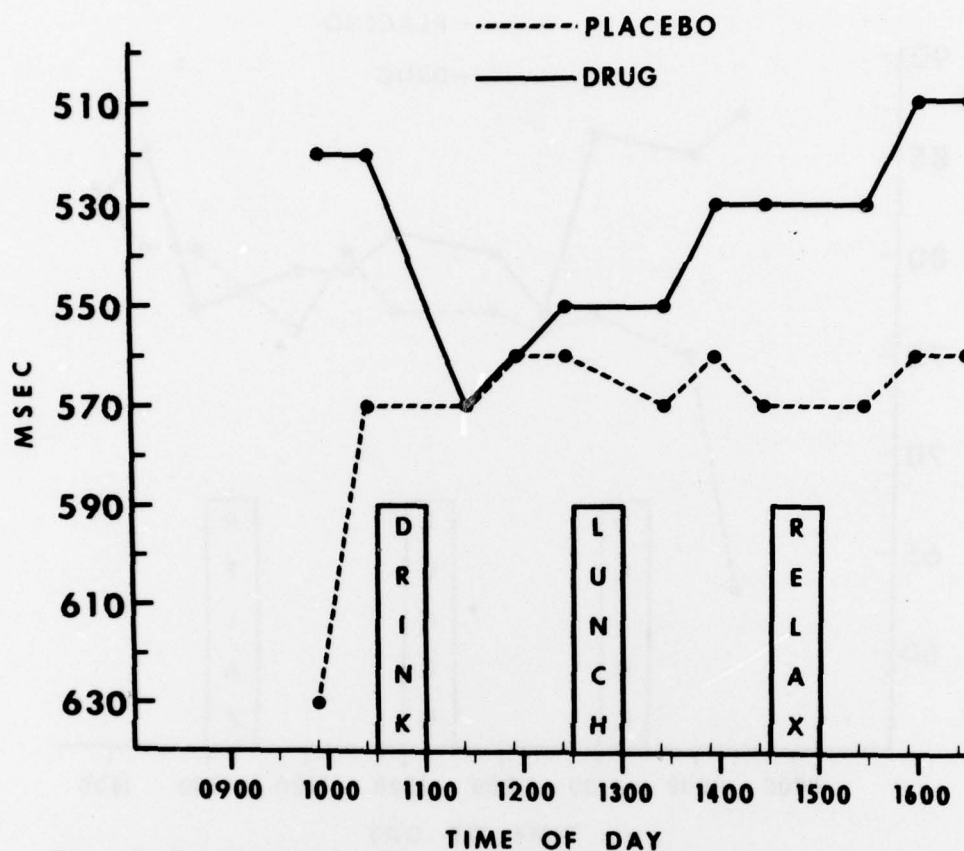


Figure 4. Mean latency of correct responses on the Wilkinson Four-Choice Serial Reaction Time Task as a function of testing session. Smaller reaction time indicates better performance. Tick marks are placed at the approximate time of testing within a half-hour session.

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performance, but none of these changes correlated significantly with drinking history. Evidence is considered that the present ethanol dosage (0.9g/kg) may not have been sufficient, that a wider range of drinking histories was needed, and that electrophysiological/psychophysical measures may be more useful than the present performance and mood tests in the search for measures of acquired tolerance to ethanol in social drinkers.

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